

VAPOR DEGREASING With Chlorinated Solvents

By WALLACE U. SEILER*

IN THE PROCESSING of metals and in the manufacture of various metal articles, it is essential that various types of soils, scales, and coatings be removed. It would perhaps be well to mention briefly the various ways that have been developed for cleaning metals before discussing in detail the subject of vapor degreasing.

The cheapest cleaning solvent is, of course, water and a number of water-base cleaning agents have been used. Alkaline solutions containing caustic soda, soda ash, trisodium phosphate and sodium silicate in an infinite number of combinations have been used. These solutions react with oils and greases by a process known as saponification. This produces a soap-like mixture having good detergency and cleaning action on metals.

Emulsion cleaners are also rather widely used and consist of mixtures of water and solvents, usually of the naphtha type, that are intimately and uniformly mixed with the aid of an emulsifying agent.

Liquid solvents are also used in metal cleaning, mainly where oils and greases are to be removed. Various active grease solvents can be used in the liquid state as a bath or as a spray. These solvents may be of the petroleum or naphtha type, or they may be chlorinated materials such as carbon tetrachloride, trichloroethylene or perchloroethylene.

Vapor Degreasing

Still another method widely used for cleaning metal objects is vapor degreasing. This is also a solvent cleaning process but in this case the metal objects to be cleaned are placed in the hot vapors being evolved by the boiling solvent. Inasmuch as elevated temperatures are involved, the use of flammable petroleum solvents is not a safe practice and as a result vapor degreasing is practically always done with one of the chlorinated hydrocarbon solvents such as trichloroethylene or perchloroethylene.

At this point it would perhaps be well to define the process of vapor degreasing. Basically, vapor degreasing is a process for the cleaning of metals or other nonporous materials by suspending them in the vapors being evolved from boiling solvents such as trichloroethylene or perchloroethylene. The parts, being relatively cool, condense the trichloroethylene or perchloroethylene vapors on them, which almost instantly dissolve any oil or grease films and wash them away. Gradually the parts reach the same temperature as the vapors. At this point condensation ceases and the

izing, pickling, assembly, inspection or packaging.

History Of The Process

THE PROCESS of metal cleaning by means of solvent vapors was first revealed in a German patent issued in 1909. This particular patent covered a process and equipment for degreasing metal objects before galvanizing by means of volatile solvents. Since at this time the industrial use of nonflammable chlorinated solvents was uncommon, this particular equipment utilized flammable petroleum solvents or benzene. One of the features of this unit was elaborate auxiliary equip-

Machine for cleaning automobile components in baskets provides for vapor-spray-vapor cleaning.
(Canadian Hanson & Van Winkle Co.)



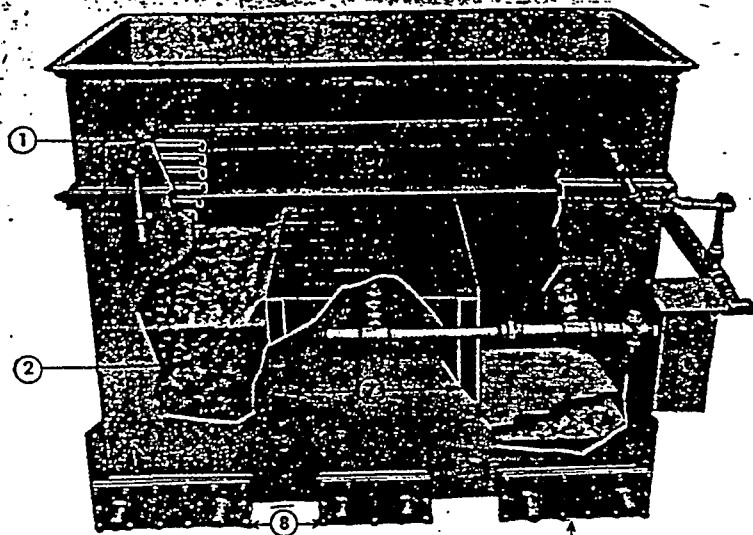
parts can be withdrawn from the machine clean and dry. Here we have the basic feature of vapor degreasing that makes it such a valuable tool in the cleaning of metals.

The solvent condensing on the parts is always freshly distilled and free of any contamination. The metal parts are being rinsed in a pure solvent which means that no residual film of grease or oil will be left on the parts when they are removed from the cleaning bath. It has been rather well stated that vapor phase degreasing can be used for the removal of oil, grease, tar, gum, wax, fat, rouge or metal chips from metal parts after stamping, threading, cutting, machining, grinding, polishing, buffing or quenching, and in preparation for electroplating, enameling, rustproofing, galvan-

ment for introducing carbon dioxide gas to reduce the fire and explosion hazard.

The vapor degreasing of metals did not advance very rapidly following the issue of this German patent. Further developments in the solvent vapor cleaning of metals did not come about until the late twenties when trichloroethylene and perchloroethylene became available in commercial quantities. An English patent of 1927 describes the process of vapor degreasing very much as it is practiced today. This patent describes a bucket-like apparatus with cooling coils in the lid and heating coils in the bottom, constructed to support the metal parts to be cleaned. Trichloroethylene was placed in the apparatus and the metal to be cleaned was preferably

*Technical Service and Development, The Dow Chemical Co. Paper presented to Montreal Chapter American Electroplaters Society



Sectional view of liquid-liquid vapor degreaser, hand operated. (Courtesy G. S. Blakeslee & Co.)

held in a suspended basket. It was further specified that the coils in the bottom were heated with steam and the coils in the top were cooled with water.

From this point, the patents began to come thick and fast in Western Europe, Canada and the United States. At the present time a large number of patents exist describing various modifications of the basic principles outlined in the earlier original patents.

The use of the vapor degreasing process for cleaning metals has grown by leaps and bounds. At the present time the number of vapor degreasers in operation in Canada and the United States probably is in excess of 25,000 units. Some idea as to the magnitude of vapor degreasing operations is evident from the fact that almost 200 million pounds of solvent is used per year in the United States and Canada for metal degreasing operations.

It has been mentioned briefly that trichloroethylene and perchloroethylene are the solvents most widely used in vapor degreasing operations. Perhaps it will be well to discuss these solvents in more detail and explain why they fit into vapor degreasing operations so well.

In the first place, obviously the solvent used must have excellent dissolving powers for oils, greases, waxes, and other types of soil usually encountered in metal working operations. Both trichloroethylene and perchloroethylene are excellent grease and oil solvents as are a number of other types of organic liquids.

Next in importance, the solvent and its vapors should be noninflam-

mable and free from any explosion hazard. At this point we must eliminate all of the industrial organic solvents with the exception of certain chlorinated hydrocarbons of which trichloroethylene and perchloroethylene are examples.

Other important properties required in a vapor degreasing solvent are low toxicity, high stability, low corrosion rate and moderate cost. When all factors are considered, trichloroethylene and perchloroethylene are the ideal solvents for the vapor cleaning of metals.

Trichloroethylene is a pure chemi-

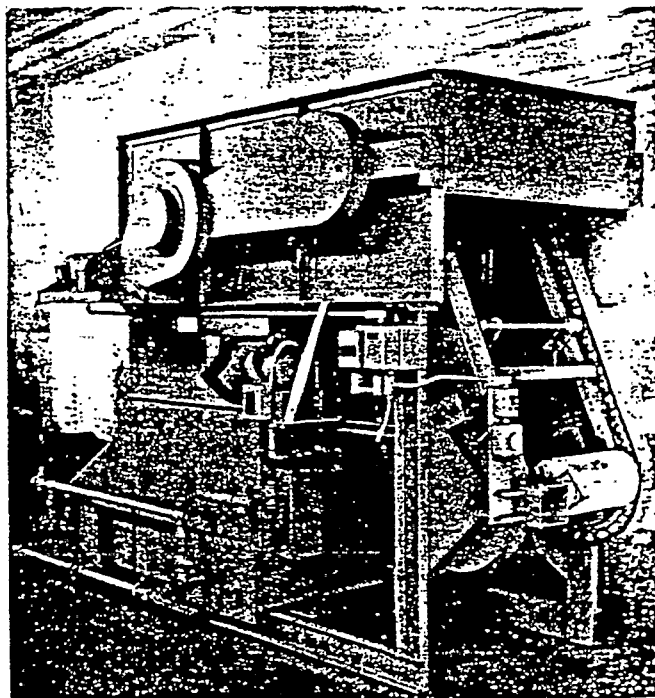
cal compound having the formula C_2HCl_3 . It is a liquid about 1.5 times as heavy as water, boiling at approximately 188 F. One factor that makes it an excellent material for vapor phase degreasing is its very low latent heat of 104 B.t.u. per pound, which is only about one tenth that of water. In other words, a given amount of heat energy will produce about nine times as much trichloroethylene vapor as water vapor. This means that large quantities of trichloroethylene vapors are produced economically for thorough cleaning of the metal parts immersed in them.

Another outstanding property of trichloroethylene is the fact that its vapors are approximately 4½ times as heavy as air. The trichloroethylene vapors therefore settle to the bottom of the degreaser tank and their level can be readily controlled, thereby minimizing solvent losses.

Perchloroethylene, with a formula of C_2Cl_4 , has a boiling point of 250 F., considerably higher than the boiling point of water. This makes perchloroethylene a particularly effective solvent for removing oil and water simultaneously from metal parts. Perchloroethylene, like trichloroethylene, has a low latent heat and a high vapor density, both factors being definitely advantageous in vapor phase cleaning.

The chlorinated solvents used in vapor degreasing are not chemically pure trichloroethylene or perchloro-

Automatic liquid-vapor degreaser which handles both rotary and flat baskets. (G. S. Blakeslee & Co.)



ylene. It is a chemical structure such that the composition of the solvent and oxygen have a great effect on the stability of the solvent. It is difficult to produce hundreds of thousands of these solvents as they are being issued in large quantities. Much has been said about the toxicity of carbon solvents. It is pointed out that perchloroethylene has a relatively low toxicity. It is stated that the concentration of the solvent is up to 200 ppm in the regular air. While these solvents are in excess, they are not dizziness. There is evidence to show that perchloroethylene is a permanent organic solvent. Most metals are easily cleaned by trichloroethylene. In use today, the equipment is simple and easy to operate. It is previously mentioned that it is used in rectangular tanks. The solvent is vaporized by heaters and a denser, or element, is used to separate the solvent from the vapors. The solvent is then used to clean the greases. The accumulation of the solvent is provided for the solvent of the container. The basic greaser.

ALTHOUGH it is quite simple to deal with and engineering the development of the solvent cleaning problems.

Starting itself, the very pretty view of zinc-applied spray is the use has been the use creates 50% or

ethylene. It has been found that the chemical structure of these solvents is such that they are subject to slight decomposition in the presence of light and oxygen. Many years of research have gone into the development of stabilizers for these solvents which have practically eliminated this difficulty with decomposition. Hundreds of patents have been and are being issued on various types of stabilizers and thousands of materials have been tested.

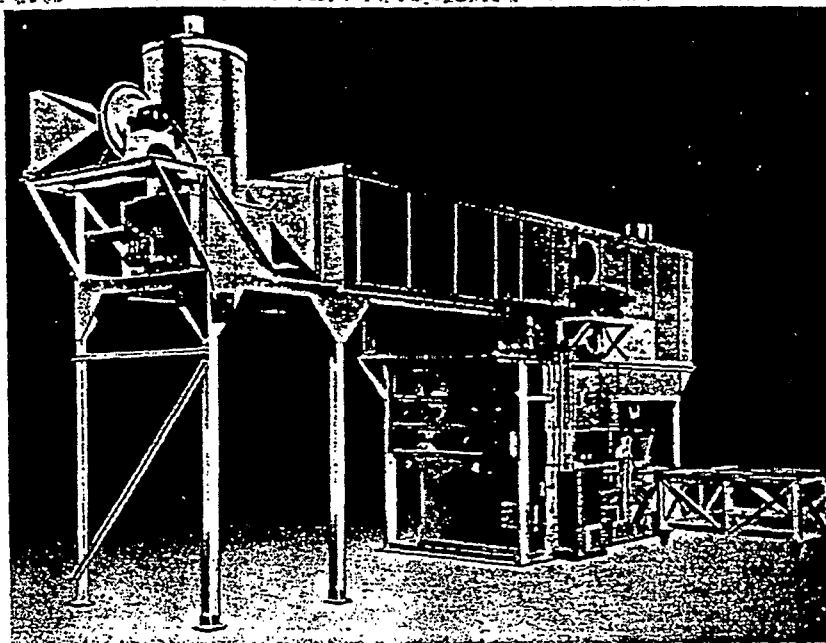
Much has been said about the toxicity of the chlorinated hydrocarbon solvents. It would be well to point out that trichloroethylene and perchloroethylene are both relatively low in toxicity. Most authorities state that a concentration of up to 200 ppm can be tolerated for a regular eight hour working day. While these solvents, when breathed in excess, will produce headaches and dizziness, there is very little evidence to indicate that any permanent organic damage is done.

Most metalworking men are probably familiar with the conventional trichloroethylene vapor degreaser in use today. It appears to be a relatively simple and foolproof piece of equipment basically not much different from the equipment described previously in the 1927 English patent. It usually consists of an open rectangular tank with a pool of solvent in the bottom. The solvent is vaporized by steam, gas, or electric heaters and a water-cooled condenser, or sometimes a thermostatic element, controls the level of the solvent vapors. Since contamination of the solvent is inevitable and oils, greases and residues gradually accumulate, some means must be provided for periodically distilling the solvent so that it can be freed of contaminants. In brief, those are the basic features of a vapor degreaser.

The Equipment

ALTHOUGH SUCH a unit appears quite simple at first glance, a great deal of time and money for research and engineering has been spent in the development of vapor-phase solvent cleaning equipment and many problems have had to be solved.

Starting with the degreasing tank itself, various manufacturers have pretty well standardized on the use of zinc-coated steel, the zinc being applied by galvanizing or metal spray methods. Recently, however, the use of stainless steel clad tanks has become more popular. Although the use of stainless steel clad increases the cost of the machine about 50% or more, it is frequently justi-



Combination degrease and paint setup, in which the work is hung on the conveyor of the degreaser and goes continuously through the degreaser, through the paint dip, through the paint oven, and back to loading point. (Photo Canadian Hanson & Van Winkle Co.)

fied by the resulting longer life of the unit. When moisture is present in the degreaser, an especially corrosive condition is encountered at the condensing area where solvent and water vapors condense simultaneously. It is in this zone that the conventional zinc-coated tank fails first.

The choice of the heat supply is another important factor to be considered. It can be either steam, gas or electricity. Steam heated degreasers are the most common in the average industrial plant where process steam is usually available. It is generally recommended that trichloroethylene units be operated on steam at 10 to 15 psi gauge. This produces a maximum temperature of about 250 F., which is well below the thermal decomposition of trichloroethylene and is ample to distill the trichloroethylene from the residual oils and greases that accumulate. Perchloroethylene degreasers are usually not operated on steam because perchloroethylene with its boiling point of 250 F. requires the use of 60 pounds gauge steam, which is not always readily available.

The use of a gas flame for heating degreasers is confined mostly to the large units. Gas-fired equipment requires additional safety thermostats in the liquid bath to prevent overheating and decomposition of solvent and sludge. Gas-fired units must also have carefully constructed flues to carry away the products of combustion. These are necessary be-

cause decomposition of solvent vapors will occur in the vicinity of open flames, products of the decomposition being undesirable from the standpoint of corrosion and toxicity.

The third method of heating the solvent, that is by electricity, is confined for the most part to comparatively small units. These units have usually been designed for use with perchloroethylene. Electrical heating has a definite advantage in that it allows the design of completely portable vapor phase degreasing machines. This is the case because the vapor level can be readily controlled thermostatically instead of by means of water-cooled coils. The electrically heated degreaser requires only a suitable electrical outlet for its operation while the steam heated unit must be piped up with water and steam, and the gas-heated unit must be piped to gas and water and in addition have a permanent flue. Although electricity is an expensive heating medium, the power is on in an electrical degreaser only about half of the time. This tends to bring the heating costs for steam, gas, and electrically heated units more nearly in line.

Controlling Vapor Level

Having established a method for vaporizing the solvent, a means must now be provided for controlling the level of the vapors. This is accomplished in steam and gas heated units by placing a jacket or coil, or

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Vapor Degreasing

(Continued from page 213)

sometimes both, around the perimeter of the tank and circulating cooling water. The solvent vapors upon reaching this cooling zone condense to a liquid and are carried back into the bottom of the degreaser or into a separate tank. With machines of this type, it is the usual practice to place a safety thermostat above the normal vapor level. The purpose of this control is to automatically cut off the heat and prevent loss of solvent in the event that the cooling water is not turned on.

The vapor level in electrically heated units can be controlled very satisfactorily by means of a thermostat on the vertical wall of the degreaser. In such a unit the solvent vapors rise until they reach the thermostat. The thermostat then opens a relay switch that shuts off the electricity to the heaters. Within a few seconds the solvent vapor level drops away from the thermo-

vapor losses. This area is known as the freeboard and by experimental tests, it has been established that the height of the freeboard should be from one half to six tenths of the open width of the degreasing tank. Certain unusual installations may require an even greater freeboard.

Solvent Contamination

In vapor degreasing it is obvious that the solvent is gradually picking up soluble oils and greases from the work being cleaned. As the amount of oil dissolved in the solvent increases, the boiling point of the solvent-oil mixture gradually rises. It is recommended that trichloroethylene degreasers not be operated beyond the point where the boiling point of the dirty solvent exceed about 195 F., which occurs when the oil concentration reaches about 20% or 25%. Similarly, it is recommended that perchloroethylene units not be operated at temperatures above 260

and condenses pure solvent on the cooling coils. A gutter or trough located beneath the coils catches the pure, distilled solvent as it drips from the cooling coils and carries it to a separate storage tank or compartment. Distillation is continued until most of the solvent has been separated, after which the oily residue is dumped. In some large installations the dirty solvent-oil mixture is removed from the degreaser and placed in a regular solvent still that is entirely separate from the degreaser.

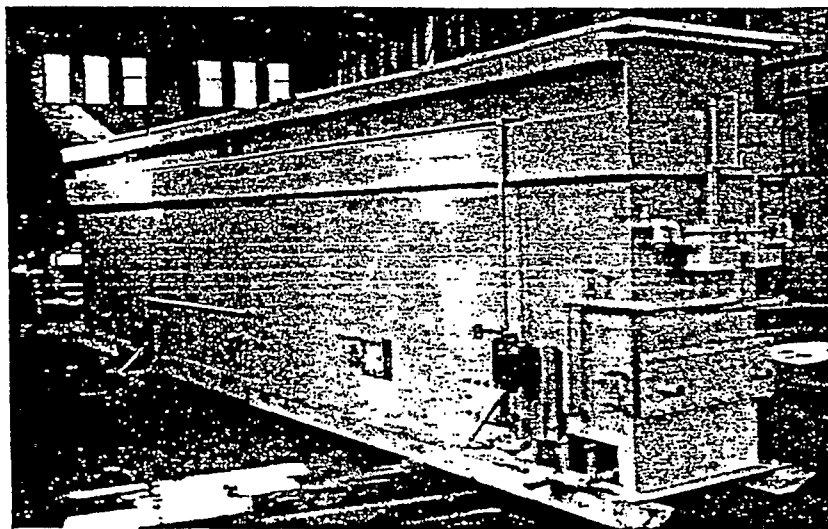
In nearly all degreasers a water separator is provided. All of the freshly distilled solvent is passed through this piece of auxiliary equipment. The purpose of the water separator is apparent from its name. Small quantities of water almost inevitably collect in a degreaser, either coming from the work, or from the atmosphere. The presence of the water in the solvent tends to increase corrosion and solvent losses and it is therefore desirable to remove it as completely as possible. The water separator accomplishes the removal of water through a system of baffles inside a small tank. Its action depends on the difference in density between the chlorinated solvents and water.

While practically all vapor degreasers using chlorinated solvents have the various essential features just described, there are many different modifications in design. Vapor degreasers vary in size from small bench-type units less than a foot square used in jewelry manufacture up to huge continuous units 75 to 100 feet in length that are used in the automobile industry.

Immersion Has Its Place

IT HAS BEEN found in practice that immersion in liquid solvent or a high-pressure spray of solvent greatly assists the regular vapor phase degreasing. This is especially true where tightly adhering solid particles of dirt are present. In order to take advantage of spray and immersion, a number of systems have been devised. It is an essential feature of all these systems that the last cleaning step consists of withdrawing the work through the solvent vapors so that pure condensed solvent rinses the work completely free of oil or grease.

Many degreasers have electrically operated centrifugal pumps and spray nozzles as auxiliary equipment. With such an arrangement the work in the vapor degreaser can be sprayed with a high-pressure stream of hot solvent which assists in dislodging insoluble particles. Sol-



Degreaser used in the aircraft industry for cleaning 30-foot spars. (Photo Canadian Hanson & Van Winkle Co.)

stat and the power is restored. In this manner the vapor level fluctuates back and forth over a range of two or three inches as the power goes off and on. Since no water lines are required, as previously mentioned, such a unit has the advantage of complete portability.

The cooling coils or thermostats are never placed at the top edge of the machine. Instead the walls extend for some distance above the desired vapor level. This wall area above the vapor level serves a definite purpose in reducing the effect of stray air currents, thereby reducing

F. The reason for this is twofold: if temperatures are allowed to go much above these limits some decomposition and corrosion are likely to occur. In addition, the generation of vapors will be considerably diminished, since less heat will be transferred.

In order to separate the solvent from the oil, some means of solvent distillation must be provided. In many of the smaller machines the degreaser itself functions as a still. This is accomplished by a simple and ingenious method. The degreaser, of course, continually distills

vent losses with such a system, however, are likely to be large unless the spray is operated carefully. Machines of this type are generally referred to as Vapor-Spray-Vapor units.

In another common type of machine the bottom part of the degreasing tank is divided into two sections by means of a dam. In one compartment the heating coils boil and vaporize the solvent in the conventional manner. The condensing solvent on the walls runs into another compartment and eventually overflows the dam and runs back into the vaporizing compartment. With a machine of this type it is possible to immerse the work in warm solvent and then withdraw the work into the solvent vapors where sufficient condensation occurs to give a thorough rinsing action. Degreasers of this type are known as warm liquid-vapor machines.

Vapor degreasers, having three separate compartments, are also used. These are designated as boiling liquid—warm liquid-vapor units.

Here the work is first placed in a bath of boiling solvent where the violent convection currents in the boiling chlorinated solvent assist in

soil removal. From the boiling solvent the work goes into a bath of warm solvent where it cools below the boiling point. This is a necessary step in order that the final vapor rinse be effective. When the work has cooled sufficiently, it is raised into the boiling solvent vapors for a final cleaning.

Mechanized For High Production

Small vapor degreasers are usually batch type units in which the work is handled manually. Larger units are frequently continuous in operation with the work being moved along on conveyors. The overhead monorail type of conveyor is frequently used. Crossbar type conveyors on which parts or baskets of parts can be hooked are also commonly used. Conveying screens are found in some machines. Here the parts are dumped in random fashion on a moving screen that carries them through the degreaser.

The various modifications in conveyor design and general equipment layout are usually dictated by the space limitations of the installation. In some installations the work passes straight through the machine to emerge some distance away from the point of entry. In other instal-

lations the work doubles back on itself inside the degreaser in a kind of "Ferris-wheel" arrangement, so that an operator can stand in one location, place dirty work on the conveyor for entrance into the degreaser, and take off the clean, dry parts as they emerge from the unit.

Installation Precautions

CONSIDERABLE THOUGHT and care should be given to the installation of a vapor phase degreaser. A properly installed vapor degreaser can be operated in perfect safety, but a poorly installed machine can be a hazard and an unnecessarily expensive piece of equipment to operate. It should be remembered that the escape of large quantities of vapor may be a health hazard and definitely is a needless expense.

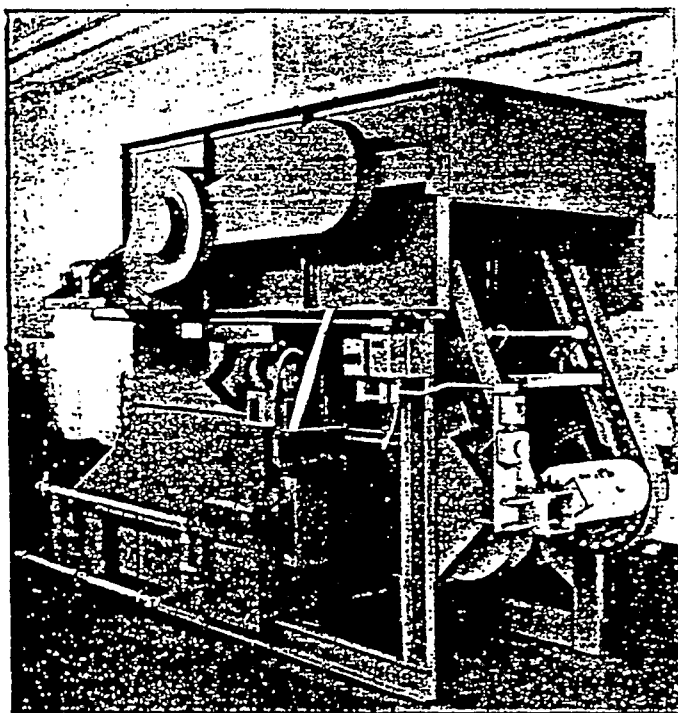
Vapor degreasers should, preferably, be set up in a fairly large room in order that solvent vapors may be readily dissipated. If it is necessary to install a vapor degreaser in a small room, exhaust fans should be provided to give a gentle movement of air away from the operator.

Although a gentle movement of air is desirable, a degreaser should never be installed where there is a rapid movement of air or draughts. Care should be taken to avoid installations near unit heaters, doors, or windows. Strong movement of air across an open degreaser will produce a turbulence that causes excessive quantities of solvent vapors to be driven out of the machine. If it is necessary to set up a machine in an area of strong draughts, it is desirable to set up auxiliary baffles to break up the air currents.

Vapor degreasers must not be installed in close proximity to open flames or very hot surfaces unless the combustion products are carried outside of the building. As mentioned previously, at very high temperatures, in the neighborhood of several hundred degrees, the degreasing solvents begin to decompose into toxic and corrosive compounds. Welding operations, either gas or electric, should not be conducted close to a vapor degreaser that is in operation.

Economy Of Materials

Since trichloroethylene and perchloroethylene, in common with many other chemicals, are currently in rather short supply, it would be well to point out some of the good operating practices that will help stretch the degreasing solvent without any sacrifice in the quality of work produced. It should also be remembered that cutting down on solvent losses is not only economic-



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ally sound, but also results in less contamination of the surrounding atmosphere.

It has been established that solvent is needlessly lost when the degreaser is left idling for long periods of time. Although the condensing arrangement on a well-designed vapor degreaser is very efficient, small solvent losses will occur under idling conditions. If, because of the irregular flow of work, it is necessary to keep the degreaser heated at all times, it is wise to see that the top of the unit is covered whenever possible. It seems almost too obvi-

ous to mention that in starting up a vapor degreaser, the cooling water should be turned on before heating the solvent and in shutting down that the cooling water should be left on until the solvent is cooled.

Where work is handled manually it should be pointed out that wooden frames and ropes for holding the work should not be introduced into a vapor degreaser. Porous materials of this type readily absorb solvent and cause excessive solvent losses.

Work should be introduced into the degreaser so as to disturb the vapor as little as possible. Where

the vapor level is violently disturbed vapor losses are certain to increase. To prevent such losses do not overload the degreaser so that there is a large drop in the vapor level. In such instances the solvent vapor mix with air that has drawn into the unit, resulting in less efficient condensation. If work is placed in the unit in a metal basket the basket should not be so large that it acts as a piston and forces out solvent vapors into the surrounding atmosphere. The rate at which work is lowered into and raised out of the machine is also important in maintaining a reasonably constant vapor level. It is a generally accepted fact that work should be moved in and out of the degreaser at rates no greater than 11 or 12 feet per minute.

It has previously been mentioned that the use of portable solvent sprays in conjunction with the vapor degreaser sometimes results in higher solvent losses. This is particularly true if solvent spray is held above the general vapor level. The resulting turbulence in such instances increases vapor losses appreciably.

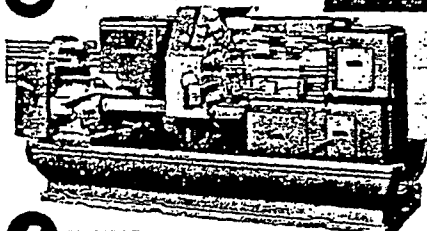
It has been mentioned that water in the degreaser is an undesirable condition from the standpoint of corrosion of equipment. Water is undesirable also from the standpoint of solvent losses. When excess water is present so-called white "ghost vapors" are formed which, being less dense than pure solvent, are more difficult to condense. The formation of these mixed solvent-water vapors therefore results in abnormal solvent losses.

Excessive losses of liquid sometimes occur when parts are of such shapes that they trap condensed solvent. In these cases it is worth while to stack parts in such a way that a minimum of liquid solvent is trapped. If it can be done without damaging the work tumbling of the parts will also prevent trapping and dragging out of liquid solvent.

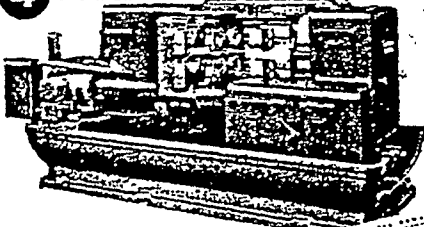
The work should be left in the machine until it has reached the temperature of the vapors and no longer condenses liquid solvent on it. When this condition has been reached the work can then be withdrawn clean and dry with a minimum loss of solvent.

Another possible source of solvent loss is incomplete distillation in which excessive quantities of solvent are left in the distillation residues. In a small unit which is self-distilling little can be done to eliminate these losses. In larger systems

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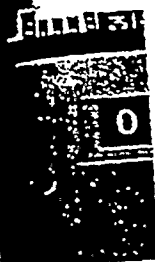
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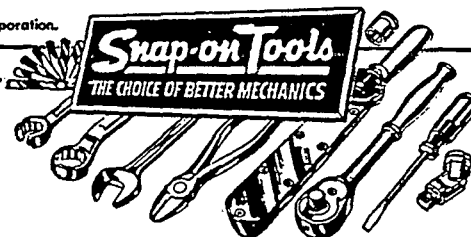


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where a separate still is used, steam can be fed into the bath residues for a more complete recovery of the degreasing solvent from the oils and greases.

Despite the fact that distillation unavoidably results in some loss of solvent, this important phase vapor degreaser operation should not be neglected. No hard and fast rule can be laid down as to when distillation is necessary because it depends entirely on the type and quantity of work being processed. Adequate distillation of solvent with thorough cleaning of the degreaser sump is the best way to avoid troubles with solvent breakdown since the accumulation of dirt and metal particles around the degreaser heating surfaces result in localized overheating of the solvent. For this reason careful attention should be paid to the accumulation of soluble and insoluble residues.

Every metal working industry that is faced with the problem of removing oil, dirt and other residues from metal surfaces can use vapor phase degreasing to an advantage. There are machines designed to handle practically any desired volume of work. The equipment is compact in size and when operated in accordance with the manufacturer's recommendations is practically free of any hazard. The equipment operates economically and efficiently producing work that is clean and dry and ready for further processing, assembly, inspection, or packaging.

Aerial Tramway

Consideration is now being given to the erection of a 10-mile aerial tramway to ferry supplies over the 9,000-ft. Cascade Mountains in Northern British Columbia to the site of the development of the Aluminum Co. of Canada in Northern British Columbia.

Possibility of such an air-lift is now being studied by Alcan and the B. C. Department of Lands and Forests. If practical, a two-in. cable will operate from Kemano on the Pacific side of the tunnel site to the crest of the mountains and beyond. An attachment will be arranged to bridge the gap between the skyline and Tahtsa Lake, first in the series to be dammed for hydro power.

The sky-lift will be used to ferry supplies from Kemano to the first dam project. In slack times the cable will be run the other way to carry surplus logs over the mountain to tidewater on the Pacific side.

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